



19970124 072

**LOOKING TOWARDS THE FUTURE
AIR NAVIGATION SYSTEM:
WILL FREE FLIGHT HAMPER
GLOBAL REACH?**

Graduate Research Paper

Joe Craig Herron, Major, USAF

AFIT/GMO/LAL/96N-2

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

DTIC QUALITY INSPECTED 3

AFIT/GMO/LAL/96N-2

**LOOKING TOWARDS THE FUTURE
AIR NAVIGATION SYSTEM:
WILL FREE FLIGHT HAMPER
GLOBAL REACH?**

Graduate Research Paper

Joe Craig Herron, Major, USAF

AFIT/GMO/LAL/96N-2

Approved for public release; distribution unlimited

DTIC QUALITY INSPECTED 8

The views expressed in this graduate research paper are those of the author and do not reflect the official policy or position of the U. S. Government, the United States Air Force, or the Department of Defense.

**LOOKING TOWARDS THE FUTURE AIR NAVIGATION SYSTEM:
WILL FREE FLIGHT HAMPER GLOBAL REACH?**

Graduate Research Paper

Presented to the Faculty of the Graduate School of
Logistics and Acquisition Management
of the Air Force Institute of Technology
Air University
Air Education and Training Command
in Partial Fulfillment of the Requirements for the
Degree of Master of Air Mobility

Joe Craig Herron, B.S., M.A.

Major, USAF

November 1996

Approved for public release; distribution unlimited

Acknowledgments

Thanks to the members of my family who have given me the strength to endure another year in search of education, without whose cooperation, time, and love this project would never have been completed.

Joe Craig Herron

Table of Contents

	Page
Acknowledgments	ii
Abstract	v
I. Introduction	1
The Future	1
Air Mobility Command	2
Statement of the Problem	3
II. Literature Review and Background	4
Introduction to the Future Air Navigation System (FANS)	4
What is FANS?	5
Communications	5
Navigation	6
Surveillance	7
Air Traffic Management (ATM)	7
FAA Mission Needs Statement	7
FANS Implementation	10
Free Flight	11
Free Flight Concept	12
Free Flight Benefits	13
Free Flight Stakeholders	14
Free Flight Progress	14
Europe	15
Tomorrow	16
Air Mobility Command	16
1996 Air Mobility Master Plan (AMMP)	17
Modernization Needs for Multiple AMC Aircraft	17
Navigation and Safety Equipment Master Plan	18

	Page
III. Issues	20
Introduction	20
Technology	20
Radical Concepts	23
Cost	24
IV. Alternatives	27
Introduction	27
Alternative One	27
Alternative Two	28
V. Conclusion	30
What Remains for Tomorrow?	30
Future Study	31
Bibliography	33
Vita	35

Abstract

Budget constraints are forcing prioritization on future spending for Air Mobility Command's weapon systems. As the airplanes age, some of the parts that are worn out become too expensive to replace. Modernization of avionics and communication packages are becoming a necessity based on the rapid implementation of the Future Air Navigation System (FANS) and Free Flight. The purpose of this study is to understand how the implementation of FANS will affect the Air Mobility Command's Global Reach Mission in the 21st Century. A background and literature review will show what elements comprise FANS and Free Flight. The strategic planning of the Air Mobility Master Plan (AMMP) and a new directive closes the review. The main issues of technology, concepts, and costs will be discussed along with the two alternatives available to AMC for future emphasis. The study concludes with the emphasis that a new planning method has to be implemented. The priority for avionics and communications upgrades is now. The operations tempo will not slow down in the near future. The policy of Global Reach will continue to be called upon. We must see that unrestricted operations in the FANS and Free Flight environment continues.

LOOKING TOWARDS THE FUTURE AIR NAVIGATION SYSTEM:

WILL FREE FLIGHT HAMPER GLOBAL REACH?

I. Introduction

The Future

Over the next ten years there will be significant improvements in the navigation performance of modern aircraft because of the implementation of future oceanic Air Traffic Control (ATC) systems such as Data Link (DL), and the concept of Automatic Dependent Surveillance (ADS) using the Global Navigation Satellite System (GNSS). These are integral parts which make up the overall environment known as the Future Air Navigation System (FANS). FANS is a way of using new technology to enhance communication links between aircraft and air traffic controllers; improve air navigation safety; and increase air traffic controller's capacity to monitor flights.

Because the implementation of FANS requires special design considerations, the civilian airline sector and aircraft equipment manufacturers have an immediate problem of deciding, in difficult economic times, whether to proceed with the retrofitting of current aircraft systems and designs of future aircraft. Industry needs a reliable prediction

of the benefits it will receive from the new system before it is willing to invest the large amount of money it will take to implement the change.

Air Mobility Command

Modernization of the air mobility fleet is [United States Transportation Command]'s No. 1 equipment priority. Without a robust and long-term commitment to modernization, our air mobility forces will become the weak link in the Defense Transportation System. To sustain and improve our use of non-lethal air power as the first weapon of choice we should make a definitive decision on the modernization of the airlift fleet this year. (Rutherford, 1995)

Except for the new C-17, the air mobility fleet is an aging fleet based on decades of old technology, that is in constant need of repair. The requirements to modernize the fleet must also take into consideration reliability and maintainability issues as the fleet continues to be flown at a high rate to meet National Objectives. Decreasing military budgets have to be apportioned wisely based on the criticality and need per weapon system. Other factors must also be monitored to give consideration to potential threats that loom on the horizon. For example, there is currently a lack of understanding by many in the air mobility arena of the Federal Aviation Administration's plan to implement the concept of Free Flight, which is a part of FANS. Free Flight is Dynamic Air Traffic Management. More specifically, the ultimate goal of Free Flight is to allow pilots to choose their own routes, speeds, and altitudes in real time--taking advantage of favorable winds and avoiding rough weather. To implement Free Flight, the capabilities of the Global Positioning System (GPS) and Data Link (DL) are the major equipment requirements.

Currently there are no air mobility aircraft that meet the system requirements for FANS and Free Flight. Funding dollars are identified for some of the equipment that is required for the system but not all of it. The purpose of this report is to educate the air mobility community on FANS and its adoption by federal aviation authorities, civilian industry, and the international community. If the Air Mobility Command does not push for mobility aircraft to receive the necessary upgrades to fly in the FANS arena now, Global Reach could become too costly to achieve later.

Statement of the Problem

The purpose of this report is to investigate how the implementation of the Future Air Navigation System (FANS) will affect the Air Mobility Command's Global Reach Mission in the 21st Century.

II. Literature Review and Background

Introduction to the Future Air Navigation System (FANS)

To develop a basic understanding of FANS, there are numerous pamphlets and other organizational handouts produced by two aviation organizations who describe the subject matter in great detail.. One of these organizations is the International Air Transport Association (IATA) which is a non-governmental organization that participates in the work of the International Civil Aviation Organization (ICAO). The ICAO was created in 1944 to promote the safe and orderly development of civil aviation in the world. A specialized agency of the United Nations, it sets international standards and regulations related to the safety, security, efficiency and regularity of air transport and also serves as the medium for cooperation in all fields of civil aviation among its 183 contracting States (World Almanac 1996, 1995:845). Other non-governmental organizations that also participate in ICAO's work include the Airports Council International, the International Federation of Air Line Pilots' Associations, and the International Council of Aircraft Owner and Pilot Associations. The second organization that produces information about FANS is the Federal Aviation Administration (FAA). The FAA originally called the Federal Aviation Agency was established with the passage of the Federal Aviation Act of 1958. The FAA was created to improve government safety regulation. When the Department Of Transportation was created in 1966 the name was changed to the Federal Aviation Administration.

Today there are two important responsibilities of the FAA: (a) conducting research and development of new aviation technologies; and (b) working with the ICAO to establish and maintain worldwide aviation standards (Nader and Smith, 1994:6-13).

Most of the following information comes from basic literature of both IATA and the FAA. When other sources of information are used, they will be documented.

What is FANS? FANS, or the Future Air Navigation System, is a way of using modern technology to: enhance communication links between aircraft and air traffic controllers; improve a pilot's ability to safely navigate his aircraft; and increase an air traffic controller's capacity to monitor flights (IATA, 1996:1-6; FAA, 1996a:1-31). FANS is also known as CNS/ATM (Communications, Navigation, Surveillance, and Air Traffic Management.)

Communications. Communications satellites positioned around the equator enable moving objects, such as aircraft or ships, to communicate with each other and with fixed points on land. Messages can be sent from a cockpit, or from passengers on board, using radio signals that are bounced off one of these satellites. A station on the ground receives these messages from the satellite and routes them to their final destination which could be an Air Traffic Control unit, or an airline's operations center or the passenger's home or office. Messages to the aircraft are sent in the opposite direction.

Satellite communication systems are especially useful over oceans and other remote areas where no alternative communications systems are in place. In more densely populated areas and at airports, ground-based communication systems can still be used.

For the international telecommunication industry the key challenge is to link these alternative systems into a seamless global network, similar in concept to the Internet.

In the world of civil aviation this global network is known as the Aeronautical Telecommunication Network or ATN and is being designed to handle data transmissions (Dornheim, 1995:46). While verbal communications between pilots and controllers will still be possible, voice communication will rarely be needed. Data communications will allow information to be transmitted more concisely, accurately, and efficiently. The ATN is a concept for a worldwide data network connecting civil aviation authorities, aircraft, airline operators, and other members of the aeronautical community. Because the ATN will provide a standard means for aeronautical communications, including communications with aircraft in flight, it is of great importance to future planning. A key benefit of the ATN will be the use of inter-operable transmission media (i.e., satellite, HF, VHF, and Mode S) for air/ground communications. ATN protocols and interface standards are currently under development in ICAO and RTCA Inc. (Formerly the Radio Technical Commission for Aeronautics) working groups (FAA, 1996a: 1-8).

Navigation. With FANS, aircraft navigation is becoming safer and more accurate though the use of navigation satellites orbiting the earth. The United States has offered its military Global Positioning System (GPS) to the international aviation community, and it is in use today by a growing number of airlines. The Russian Federation has a similar system, also offered for civil use, called Global Orbiting Navigation Satellite System (GLONASS) which is not yet fully operational. Eventually, both systems will probably be used by the airlines (FAA, 1995:1-5).

GPS and GLONASS require augmentation systems to monitor signal reliability and enhance accuracy to make them suitable for civilian use. These augmentation systems are currently being developed (Clarke, 1996:99).

Navigation satellites are being used today to land aircraft on runways in good weather conditions. These types of approaches are called non-precision approach and landings. For landings in poor weather conditions, called precision approach and landings, the current Instrument Landing System (ILS) or, in certain locations, Microwave Landing System (MLS) will be in use for some time. Eventually, navigation satellite systems will be used even in poor weather conditions (FAA, 1996a:11).

Surveillance. Under FANS, air traffic controllers will continue to use ground-based radar to monitor aircraft over densely populated areas. When flying over oceans and remote areas, however, where no radar systems exist, aircraft can now relay their positions to ATC centers via communications satellites. This concept, known as Automatic Dependent Surveillance (ADS) ensures air traffic controllers know exactly where every aircraft is (FAA, 1996a:13).

Air Traffic Management (ATM). The following is the mission needs statement that provides an insight to the FAA designs on the direction and background of ATM

FAA MISSION NEEDS STATEMENT. The overall mission of the Federal Aviation Administration (FAA) is to provide a safe, secure, and efficient aviation system that contributes to national security and the promotion of U.S. aviation. The basic responsibilities of the FAA are detailed in the Federal Aviation Act of 1958 (as amended by Public Law 89 670). This Act requires that the FAA manage the national airspace for the benefit of all users and that air travel be accomplished in a safe, orderly, and efficient manner. The specific part of the FAA mission discussed in this Mission Need Statement (MNS) is that of air traffic operations and communications in support of these operations. Demand for

air traffic control (ATC) services is predicted to increase dramatically in the next 10 years. Air carrier hours flown and numbers of air carrier aircraft are expected to increase by over 50 percent. The number of Instrument Flight Rules (IFR) aircraft handled at the Air Route Traffic Control Centers (ARTCCs) and Terminal Radar Approach Control Facilities (TRACONS) is expected to increase by over 30 percent. To support the increased global air traffic demand, the International Civil Aviation Organization (ICAO) Future Air Navigation Systems (FANS) committee has identified a future Air Traffic Management (ATM) system based on a structure of communications, navigation, and surveillance (CNS) functions, which in turn support flight planning, aircraft operations, and air traffic separation on a global basis. (FAA, 1996b:WWWeb)

The ATM system of the future will provide improved services to users of the airspace system and will support the goals of increased efficiency and safety as demand grows.

Major user needs identified for the future ATM system include: the ability to select and fly an optimal route at the user's desired departure and arrival times; access to information that can be used to determine an optimal flight plan or to modify an active flight plan based on user criteria; access to air traffic and flight information services with minimal delay and error; delivery of safety-critical information and instructions to pilots with minimal delay and error; receipt of information that is current, accurate, relevant to operational objectives, easily understood, and applied (IATA, 1996b:WWWeb).

The FAA has established an operational plan for the ATM system of the twenty-first century. To realize the FANS concepts for ATM, the National Airspace System (NAS) will rely increasingly on advanced capabilities provided by ground and airborne automation systems and will require the communication and management of timely and accurate air traffic, flight information, navigation, and surveillance data in all operational domains. In this future ATM environment, it will no longer be possible to rely

exclusively on voice messages for the exchange of information. Digital data communications will become the primary means of exchanging information among NAS users and their supporting automation systems. To this end, transition from voice to data communications has been identified as a key goal for ATC (FAA, 1996a:20-23).

The Aeronautical Data Link System (ADLS) has been identified to provide many of the capabilities crucial to implementation of the future ATM system. The ADLS comprises both the services and the communications infrastructure that support aeronautical information exchange among all members of the aviation community. The ADLS services will allow the presentation and management of data to be tailored to the user's capabilities and requirements to maximize the utility of air traffic services. The ADLS communications infrastructure will implement the FAA's portion of the ATN and will provide the global air/ground data communications capability required to alleviate communications problems in the current voice environment and to support advanced capabilities in the future environment. The ADLS must support the ATM user needs identified previously and must also accomplish the following: provide a selected set of ATC, weather, flight service, navigation, surveillance, and aeronautical information and services directly to the cockpit using digital data link technology; support seamless transition for aircraft across and within all NAS operational domains, (tower, terminal, en route, and oceanic); provide a distributed networking infrastructure, which will allow communications services to be carried via any of the possible air/ground transmission technologies over the ATN and incorporate ATN protocols which utilize internationally standardized Open Systems (FAA, 1996b:WWWeb).

FANS Implementation. Starting in the South Pacific, the introduction of FANS is now spreading to other regions and gaining momentum. FANS is gradually being implemented as regions and individual countries move from traditional methods for navigation and communications to these more advanced systems.

Benefits are available today for airlines and ATS providers willing to embark upon FANS CNS/ATM implementation. The target date for global FANS implementation as set by ICAO (the International Civil Aviation Organization) is 2010 (IATA, 1996:4).

An example of the implementation of FANS in the Pacific took place in August 1995 when a United Airlines 747-400, flying from San Francisco to Sydney, Australia sent GPS positions by data link that led to key certifications of ATC stations. The aircraft was equipped with the FANS-1 suite, which combines navigation and satellite data link communications and costs approximately \$5 million per aircraft (Nordwall, 1995b:28-29).

To achieve the full benefit of FANS, air traffic control procedures will need to change and the separation distances between aircraft will need to be reduced. Ultimately, airlines hope to gain total freedom for pilots to select their routes and to change these routes in flight, safely and efficiently. This goal, known as Free Flight, will ensure the

most economic, fastest, or most direct route will be flown according to the requirements of each individual flight (Hinson, 1995).

Free Flight

Free Flight is an innovative concept that will improve the efficiency of the National Airspace System. Using supporting procedures and technologies, pilots operating under instrument flight rules (IFR) will be able to select the aircraft's course, speed, and altitude in real time. From pre-flight planning to destination parking, Free Flight provides the aviation community with maximum flexibility and safety. This concept is being developed jointly by the FAA and the aviation community. The basic concepts of Free Flight can be found throughout FAA literature and electronic dissemination on the World Wide Web.

Currently, a pilot establishes a flight plan with air traffic control. This plan requires the aircraft to fly along a specific route. Any deviation from the designated route must be pre-approved by an air traffic controller. For example, if a thunderstorm is encountered along the flight path, the pilot must notify the air traffic controller of the need to change course, and the controller would designate a course for the plane to avoid the weather. Under the Free Flight concept, the pilot will be able to choose the route, speed and altitude to achieve the desired results, notifying the air traffic controller of the new route. The pilot's flexibility will be restricted only:

- To ensure separation, when traffic density at busy airports or in congested airspace, precludes Free Flight

- To prevent unauthorized entry into special use airspace
- To ensure safety of flight.

Generally speaking, any activity that removes restrictions represents a move toward Free Flight. Full implementation of Free Flight requires varying degrees of modifications to procedures, along with the use of current and new technologies and new ground- and air-based communications, navigation, and surveillance equipment and avionics. Free Flight continues clear-cut lines of authority and responsibility between the pilot and controller. Technology will be designed to allow the pilot and controller to perform their jobs with improved accuracy, efficiency, and coordination (FAA, 1996c:WWWeb; Hinson: 1996b).

Free Flight Concept. The Free Flight idea is based on two airspace zones, protected and alert, the sizes of which are based on the aircraft's speed, performance characteristics, and communications, navigation, and surveillance equipment. The protected zone, the one closest to the aircraft, can never meet the protected zone of another aircraft. The alert zone extends well beyond the protected zone. Upon contact with another aircraft's alert zone, a pilot or air traffic controller will determine if a course correction is required. In principle, until the alert zones touch, aircraft can maneuver freely.

The protected zone, the one closest to the aircraft, can never meet the protected zone of another aircraft. The alert zone extends well beyond the protected zone and, upon contact with another aircraft's alert zone, signals that a conflict exists.

If alert zones do touch, a controller may provide one or both pilots with course corrections or restrictions to ensure separation. Eventually, most commands will be sent via data link, an integrated network of air, ground, and airborne communications systems. Additionally, onboard computers and Global Positioning System satellites will allow pilots with airborne traffic displays to choose solutions, with the concurrence of the controller. The Free Flight concept ranges from total flight-path flexibility to controlled separation due to traffic density and the complexity of traffic flow (FAA, 1996c:WWWeb; Nordwall, 1995a:38-39; Hinson, 1996b).

Free Flight Benefits. Free Flight is designed to provide the user community with the flexibility to better manage its operations and the capability to derive benefits from advanced avionics. By providing for more efficient routes, Free Flight will reduce user operating costs. Free Flight will also allow the user's aircraft to reach its destination at the prescribed time. The FAA predicts a near 70 percent increase in domestic air traffic by the year 2000, reflecting an increase from 480 million passengers in 1995 to 800 million by the end of the century (FAA, 1996c:WWWeb) Free Flight will enable air traffic controllers to accommodate this future growth through a decision support system, at a lower cost to users. By providing the user with incentives to modernize their equipment, the FAA will move to a modern infrastructure, reducing the FAA operations and maintenance burdens while increasing safety (FAA, 1996c:WWWeb; Hinson, 1996b).

Free Flight Stakeholders. Free Flight is a joint initiative of the aviation industry and the FAA. In 1994, the FAA asked the Radio Technical Commission for Aeronautics, Inc. (RTCA), an independent organization that serves in an advisory capacity to the FAA, to form a select committee to study Free Flight. The committee that convened in October 1994 was composed of representatives from general aviation, pilot and controller unions, the airline industry, civilian contractors, and government policy makers. In January 1995, the committee presented a report to the FAA Administrator defining the Free Flight concept and the first steps for its implementation. In April 1995, at the request of the FAA Administrator, RTCA formed Task Force III on Free Flight to further define the procedures, system architecture, and transition recommendations. "The Final Report of RTCA Task Force 3: Free Flight Implementation," was given to the FAA in October 1995 (Hinson, 1996a).

Free Flight Progress. Elements of the Free Flight concept are part of the current expanded National Route Program, the Central Pacific Oceanic program, and future communication, navigation, surveillance, and air traffic management technologies. The National Route Program Expansion is designed ultimately to permit aircraft flying above 29,000 feet to select their routes as alternatives to published preferred IFR routes, thereby removing the restrictions and constraints currently imposed on these users. The National Route Program Expansion is successfully using a phased approach. As of June 1, 1995, the expanded National Route Program includes all flights above 35,000 feet. In the

western U.S., the level was lowered to 33,000 feet (FAA, 1996c:WWWeb; Phillips, 1996a:27).

The FAA estimates that the National Route Program saved the aviation industry \$40 million in 1994 by allowing pilots to fly more optimal routes (FAA, 1996c:WWWeb; Nordwall, 1995a:39). The Managed Arrival Reservoir is another philosophy embraced by the FAA and aviation community for removing restrictions and moving toward Free Flight. By removing departure and en route restrictions, this procedural change maximizes the use of arrival slots to take advantage of unused capacity, ensuring the most efficient use of the airport and airspace (Nordwall, 1995a:39).

Air carriers flying in the airspace over the Central Pacific, are using advanced satellite voice and data communication to provide faster, more reliable transmission to enable reductions in vertical, lateral and longitudinal separation, more direct flights and tracks, and faster altitude clearances (Nordwall, 1995b:29).

Europe. Eurocontrol has a parallel effort within its Program for Harmonized Air Traffic Management Research -- or PHARE. Free Flight and PHARE are complementary, with more similarities than differences. Under the PHARE project, an aircrew would request a flight path, which is then approved by ground controllers who continue to maintain positive control throughout the flight, from airport to airport. Free Flight, in contrast, envisions an aircraft flying any trajectory with controller intervention

only in cases of conflict. Eventually, the two approaches will be highly compatible, if not operationally equivalent.

Both the PHARE project and Free Flight depend on some of the same enabling technologies, and several of these are already in use throughout the world. They are the key elements in the global system of air traffic management that is rapidly evolving (Morrocco, 1996:29-30; Hinson, 1996b).

Tomorrow. In the long term, technologies are needed to improve conflict identification; resolution and data transmission; and display. Direct exchange among aircraft, airline operation centers, controllers, and pilots are critical to a successful evolution to Free Flight. Such technologies include: Global Positioning System (GPS), Wide Area Augmentation System (WAAS), Traffic Alert and Collision Avoidance System (TCAS), two-way data link (TWDL), Automatic Dependent Surveillance-Broadcast (ADS-B), Aeronautical Telecommunication Network (ATN), and a decision support system including Final Approach Sequencing Tools (FAST), Conflict Probe/Resolution and Surface Management Program (Nordwall, 1996:28-29; FAA, 1995:3-6).

Air Mobility Command

The final two areas of literature review and background focus on the strategic planning documents that help direct future decisions for mobility aircraft. They provide the foundation needed to determine if Global Reach will be achieved in the next century.

1996 Air Mobility Master Plan (AMMP). The following defines the AMMP:

The Air Mobility Master Plan is a strategic plan outlining AMC's future vision and detailed plans for its total force. It uses executive-level guidance from Congressional, Department of Defense, US Transportation Command, sister service, and Air Force agencies to effectively manage the Air Reserve Component, Civil Reserve Air Fleet, civilian work force, and active duty personnel in a period marked by increasing operations tempo, aging aircraft and infrastructure, and frequent and lengthy deployments to some of the world's most dangerous regions. (AMC, 1995:Foreward)

It is in this plan where the foundation is laid to meet future requirements for the command.

Modernization Needs for Multiple AMC Aircraft. Several modernization/upgrade efforts apply to all AMC aircraft, especially those driven by the International Civil Aviation Organization (ICAO) and the Federal Aviation Administration (FAA) regulations. AMC is the lead command for the KC-135, KC-10, C-17, C-141, C-5, C-9, C-20, C-21, NDAA, and SAM aircraft. Particular equipment items for all AMC and AMC led aircraft is listed in the modifications section of the AMMP under Modifications Applicable to Multiple Aircraft. This section documents the need for equipment and capabilities applicable to multiple aircraft (HQ AMC, 1995:5-8).

The majority of AMC's aircraft are over 25 years old and aging rapidly. Although upgrades have been accomplished over the years, many of the systems are becoming extremely difficult to maintain. In some instances, the reliability is very low, and in other cases replacement parts are no longer in production. In either case, modern systems represent vast increases in reliability, maintainability, and supportability. AMC's overall fleet performance will improve with the addition of more reliable systems and the

maintenance support required will decrease. Two of the specific systems in need are avionics and communications (HQ AMC, 1995:5-8).

The FAA is significantly upgrading its air traffic management system with a global navigation satellite system, digital data communications, and advanced automation in oceanic airspace. These modernized systems support the ICAO's future air navigation systems (FANS). As the increased capabilities of the newer systems are integrated into normal operations, both organizations will increasingly restrict aircraft that does not meet the new standards. AMC must keep pace with these upgrades. "Unless AMC aircraft comply by receiving onboard equipment compatible with the new systems, they will be excluded from optimum airspace" (HQ AMC, 1995:5-8).

Navigation and Safety Equipment Master Plan. Current events have created concern over the lack of certain equipment on DoD passenger carrying aircraft. In an attempt to explore the options available to correct these deficiencies, as well as meet future requirements, a conference was convened to establish a standard equipment baseline and develop a roadmap for equipping DoD aircraft. The conference was composed of representatives from across the Air Force, FAA, and other Services. In developing a standard navigation and equipment baseline, the group considered the following: Secretary of Defense and Chief of Staff of the Air Force guidance as outlined in SECDEF memo, 26 Apr 96; current Federal Aviation Regulations (FARS); mission requirements by weapon system; and finally future growth potential that would provide DoD aircraft with unrestricted operations in national and international airspace as the world's air traffic architecture transitions to the concept of Free Flight. Once this Master

Plan is approved, it will serve as the single source document to be used throughout the DoD and academe. Chapter 4 of this Master Plan gives a proposed Free Flight Requirements Roadmap that is not included currently in the AMMP (HQ AMC/XPQC, 1996:Forward).

III. Issues

Introduction

Systems seem to change overnight when there are rapid advances in technology. What was once considered impossible is today a reality. Some elements that were once dreamed of were even bypassed by new technologies. The system of currently flying an aircraft from one location to another is outdated and in need of change. The previous chapter discussed the basic elements of FANS and Free Flight. It showed the major participants that are pushing for change to the current system and it concluded with the Air Mobility Command's framework to try to decide what direction to take to ensure a viable force to meet future needs.

This chapter will focus on three major hurdles that lie ahead for FANS implementation in the Air Mobility Command. These three issues are technology, concepts and cost.

Technology

As technology explodes, there are often setbacks where technology does not solve all the problems it is designed to fix. There are numerous cases where the new technology causes more problems than was there initially.

Citing a multitude of contractual violations and program failures, the FAA is threatening to terminate its \$475 million contract with Wilcox Electric Inc., for development of the Wide Area Augmentation System (WAAS) unless the company makes sweeping reforms (Phillips, 1996b:28). WAAS is designed to provide civilian pilots with an accurate, reliable en route navigation system using corrected signals from the Global Positioning System. GPS is one of the major elements needed in FANS and Free Flight implementation. One of the major misunderstandings is that GPS alone can perform all the desired steps in reliable navigation. Corrected signals play a large part in the overall design, especially for future precision approaches. The 1996 AMMP states, under deficiencies, for the C-17. "Current GPS equipment has no integrity monitoring capability or fault detection and exclusion equipment. Aircrews are unable to determine the accuracy of the GPS signal being received" (HQ AMC, 1995:C-17 Roadmap). This is one of the major problems of defense funding for future avionics packages. Changes in technology are happening so rapidly that contracts need to be written to ensure what is funded for the future is what is really needed for the future. The air mobility planners need to constantly update their vision of these requirements.

Another major technology that is critical to the FANS and Free Flight concept is Automatic Dependent Surveillance-Broadcast (ADS-B). The conclusion at a recent RTCA symposium is that ADS-B is clearly essential to the development of Free Flight (Nordwall, 1996:28). The air traffic control system will need the additional information

provided by ADS-B to ensure safety as separation is decreased to accommodate increasing numbers of aircraft.

One of the central elements to ADS-B is Data Link. Still unresolved is the issue of what radios and frequencies to use. The Mode-S transponder from Traffic Alert and Collision Avoidance Systems (TCAS) is currently being pushed as the leading contender. More than six thousand commercial aircraft currently have TCAS installed. The Defense Department with approximately 15,425 aircraft that operate in positive control airspace currently has no requirement for Mode-S (Nordwall, 1996:29). Stephen Brown, senior vice president, Aircraft Owners & Pilots Association said “a key point of leverage to obtain benefits is the design of an affordable Data Link for general aviation.” “There is not now an affordable Data Link for much of general aviation or regional airlines” (Nordwall, 1996:29). Data Link has not received funding in AMC, based on further review of future FAA policies on what is going to be required (HQ AMC, 1995:4.1.2.2.7;12). This could be the weakest area in AMC’s capability to meet future requirements and can not be understated. It also shows where commercial competition can lead to emerging technologies. Leaning forward in anticipation of the entire structure taking one avenue can prove disastrous when the development decides to go another direction. This is perhaps, the major reason AMC has taken such a position. The drawback is the potential to miss an opportunity while it exists.

Decisions on what ends up being the system of choice often become motivated by what a particular firm or agency has already invested money or research. Special interest then becomes the driving factor to exert influence on the decision making body.

Radical Concepts

A major push behind the modernization of the airway system is to reduce inefficiencies that exist today. The transition from an air traffic controller to that of a system observer will require extensive training in the new roles and procedures expected of ATC personnel on the ground. It will also require a change in philosophy of the pilots who will be required to become active participants in the shared responsibilities of their flight. Defining the roles and responsibilities will be hard since many of the procedures have been fixed over a long period of time. Alternatives that were once deemed impossible may be appropriate tomorrow. Procedures and human factors will be the real hurdle to Free Flight (Phillips, 1996a:27). Realizing that the human factors issue requires further study, the FAA has implemented a working group to determine future needs and requirements in this area (FAA, 1996d:19).

“As the role of the air traffic controller moves from that of controller and director to that of safety monitor and airspace manager, the relationship of the controller to the pilots in the cockpit needs careful human factor analysis” (FAA, 1996d:19). For example, a prime cause of accidents on training flights, is the gray area where the trainee has direct control of the aircraft and the instructor fails to intervene until it is too late.

The future authority relationship between aircrews and controllers as air traffic managers has the same potential for gray area accidents and needs to be addressed (FAA, 1996d:19).

Training for all of the new technology and conceptual changes are not addressed in the 1996 AMMP at all. This is another shortcoming that could result in undesirable outcomes for mobility pilots in the future. Knowledge of the workings of the system will not be achieved overnight. It will take a serious training regime with a proactive standardization and evaluation system to ensure the safety in its use. With the multitude of weapon systems in AMC, the ease of consistent training programs that can be found in the civilian workplace will also be a hindrance.

Cost

The \$5 million cost for the FANS-1 suite has already been discussed (Nordwall, 1995b:29). The cost estimates from the Navigation and Safety Equipment Master Plan for the future considerations roadmap is approximately \$1.1 billion some of which is already funded (HQ AMC, 1996:32)

On August 9, 1994, a Congressional hearing was held by The Honorable Collin Peterson on the RMB Associates study *Free Flight - Reinventing ATC: The Economic Impact* (June 1994). Testimony showed examples of waste in the current ATC system. Flights from Nashville to Boston are forced to fly 18% longer, simply to meet the needs of an antiquated, manually run system. The excess operating cost to American Airlines

for this one route is \$1 million annually. United Airlines estimates excess costs of \$670 million annually due to the ATC system and additional \$1.3 billion in lost productivity. (Baiada, 1995:1)

The Clinton Administration is requesting \$37.5 billion to fund the U. S. Transportation Department in Fiscal 1997. This includes \$8.25 billion to operate the FAA and implement upgrades to the nation's navigation and air traffic control systems. The FAA would spend \$41 million for transoceanic air traffic services and \$72 million to develop a fully digital infrastructure upgrade at terminal approach control radar facilities. It would also spend \$117 million for Voice Switching and Control System improving controller pilot communications. Finally \$74 million would be spent on the Wide Area Augmentation System (Phillips, 1996c:28). Funding is not entirely certain for 1998. Currently for 1998 there is no funding for Data Link in the FAA budget and as J. Roger Fleming says "If there is no Data Link there is no Free Flight" (Fleming, 1996; Nordwall, 1996:28).

There is an important area that needs to be included if the hurdles are overcome and the changes do take place. That area is the potential cost savings that would be generated by these changes.

A NASA study estimates that airlines in the United States could save as much as 1.47 billion dollars a year by 2005 if Free Flight is fully implemented (Coluris and Dorsky, 1995) Not only will fuel savings be affected by the more direct routing, reduced personnel will be needed to fly some oceanic flights. The savings of fifty minutes of

flying time on the San Francisco to Seoul, Korea route could eliminate a fourth pilot saving the airlines an estimated \$2.5 million a year (Nordwall, 1995b:28).

AMC's cost savings have not been calculated directly. The anticipated savings would be calculated by the amount of fuel that could be saved by participating in the same environment as the civilian airlines. If the direct routing becomes unavailable for non-compliance, due to systems limitations, then it can be assumed that fuel costs would rise based on indirect routing and non-optimum altitudes. The influence on mission effectiveness would also have to be calculated. These costs need to be estimated in future planning documents to give the needed emphasis to potential outcomes.

IV. Alternatives

Introduction

One of the main justifications for FANS and Free Flight is the prospect that growth in air travel is expected to double in the number of passengers and aircraft by the year 2015 (Hinson, 1996b). The issues which comprise hurdles to the implementation of FANS (technology, concepts, and costs) were discussed in the previous chapter.

Although there are unique problems associated with each of the issues, the most important fact to understand is the reality that change will take place. Some form of the future vision will become reality. The chief causal factor will be economics. The airlines are in the business for one reason, to make a profit. Inefficiencies are replaced by cost effective implementation of operations. There are only two alternatives for AMC to follow based on the reality that FANS and Free Flight will be implemented. The first alternative is to continue with the direction that is proposed in the 1996 AMMP. The second alternative would be to aggressively pursue the roadmap proposed by the multicommand conference and ensure that the planners stay abreast of the current directions being proposed by aviation agencies.

Alternative One

The driving force in the constrained military budget is determining how best to allocate funds and resources. There are different areas that claim their needs should

receive priority when being funded. Each AMC weapon system has unique needs on maintainability, reliability, and modernization upgrades. The 1996 AMMP talks in various locations about the need to upgrade all weapon systems to comply with future requirements of FANS and Free Flight. The consistent statement found throughout, under weapon system deficiencies is "Inadequate aircraft navigation systems. Current systems do not meet future FAA/ICAO requirements" (HQ AMC, 1995:Roadmaps). Funded items do not entirely correct these deficiencies. It is implied that until operations are affected; AMC will not aggressively pursue all of the changes needed. It is also implied that the ability to change funding exists through the utilization of Integrated Product Teams (IPTs). These teams provide a forum for integrating activities in logistics, requirements, operations, plans and also serve as a focal point for discussion of weapon systems concerns and issues. IPTs currently exist to manage most weapon systems. Cross-functional representation from throughout HQ AMC, HQ USAF, the ARC, AETC, Theater Commands, AFMC, and industry ensures that major players are kept informed while also providing a forum that facilitates faster communication and coordination (HQ AMC, 1995:5-9). Alternative One will not fulfill all of the requirements for FANS and Free Flight and would affect AMC's Global Reach mission.

Alternative Two

The priorities of equipment needs are brought forth in alternative two. The equipment baseline and future roadmap would be established in the Master Plan.

Unrestricted operations for AMC aircraft would be ensured. Replacing the AMMP as the single source document for navigation and safety equipment would help planners separate the importance for funding these requirements away from those that would be found in the AMMP. By ensuring unrestricted operations for AMC aircraft in the FANS and Free Flight environment, AMC's ability for Global Reach in the 21st Century can be achieved through alternative two.

V. Conclusion

What Remains for Tomorrow?

Sweeping changes are on the horizon concerning the world environment of air travel. Significant improvements in navigation and computer technologies have led to these changes. FANS was once an idea that could only be discussed on the visionary level. Satellites and real time communication were considered fiction. Planning future economic decisions based on these changes were not given high priority. Free Flight was not possible in the established FAA Air Traffic Control due to safety considerations. This study has shown how FANS and Free Flight are no longer visions but upcoming realities.

The three major issues affecting the implementation of FANS and Free Flight were technology, concepts, and cost. Problems can not always be corrected by continuous technological solutions. Radical changes in policy require research on potential human factors problems. Training systems have to be designed to teach roles and responsibilities for all involved. Safety can never be compromised. Cost of new technology and infrastructure is enormous. The theme of cost savings and profit potential remain as the commercial sector's prime motivation for implementation of FANS and Free Flight.

Air Mobility Command continues to forecast increased operations for the foreseeable future. The budget limitations and downsized force have required

considerable changes in funding priorities. The aging C-141 is being replaced by the command's newest airplane, the C-17. Currently there are no air mobility aircraft that meets the requirements for FANS and Free Flight. Some of the equipment needed for modernization is already funded. The 1996 Air Mobility Master Plan has been the single source document for planners. In June of 1996, HQ AMC/XPOC published a Draft Navigation & Safety Equipment Master Plan for DOD Passenger Carrying Aircraft. This plan identified a potential roadmap detailing the cost and timetable for ensuring unrestricted operations in the FANS and Free Flight environment for AMC aircraft. This study stresses the importance for the Air Staff to validate this plan to ensure AMC continues Global Reach into the 21st Century.

Future Study

There are other areas requiring further research. What will be the actual costs for AMC's non-participation in FANS and Free Flight? What will be the considerations given to non-participants? What type of routes and altitudes will the non-participants be required to fly? Fuel and other miscellaneous costs can be accurately forecast only when these questions are answered. Will military operational necessity allow for some type of waiver to allow military aircraft access to direct routings and optimum altitudes? What type of cooperation and system similarity can be found in the European and other world markets?

What will be the requirements for non-participants who are flying in these areas of the world? These are just a few of the questions that need to be answered in future review. Flexibility and planning are the key to tomorrow's challenges. Only then can we be prepared to answer them.

Bibliography

- Baiada, R. Michael. "A New Economic Model," 1, RMB Associates, (1995).
- Clarke, Bill. *Aviators Guide to GPS* (Second Edition). New York: McGraw Hill, 1996.
- Couluris, G.J. and S. Dorsky, "Advanced Air Transportation Technologies (AATT) Potential Benefits Analysis," *United States National Aeronautics and Space Administration (NASA) Ames Report*, AATT-95-001, September 1995.
- Dornheim, Michael A. "Equipment Will Not Prevent Free Flight," *Aviation Week & Space Technology*. 46 (31 July 1995).
- Federal Aviation Administration (FAA). *FAA Satellite Navigation Program Master Plan: FY 1995 - 2000*. Federal Aviation Administration Satellite Program Office (AND-510) Research and Acquisitions: For Comment Draft, 1-18 (21 August 1995).
- . *Accepting the Challenge: Global Aviation for the 21st Century*. 1-31 (1996a).
- . "Data Link Mission Needs Statement," 1 March 1996b.
- . "Free Flight," 5 March 1996c.
- . "Report of the Challenge 2000 Subcommittee of the Federal Aviation Administration Research, Engineering, and Development Advisory Committee for the Administrator of the FAA; The Honorable David R. Hinson," 1-74 (6 March 1996d).
- Fleming, J. Roger. Senior Vice President, Operations and Safety of the Air Transport Association, "On DOT and Related Agencies' Appropriations for FY 97." Statement Before the House Committee on Appropriations Subcommittee on Transportation, 27 February 1996.
- Headquarters Air Mobility Command (AMC). *1996 Air Mobility Master Plan (AMMP)*. 2 October 1995.
- Headquarters Air Mobility Command (AMC). *Navigation & Safety Equipment Master Plan for DoD Passenger Carrying Aircraft (Draft)*. HQ AMC/XPQC, June 1996.

Hinson, David R., FAA Administrator. Remarks delivered to National Airspace System (NAS) Architecture Meeting. Washington DC, 27 June 1995.

-----, "FAA and Aviation Community to Implement Free Flight," FAA News Release, APA 46-96 Washington DC, 15 March 1996a.

-----, "The Future of Air Traffic Control: Bringing Free Flight to Global Aviation," Remarks delivered to Financial Times World Aerospace Conference, 29 August 1996b.

International Air Transport Association (IATA). "FANS - CNS/ATM," *FANS Facts*. Montreal, Geneva: 1-6 (June 1996).

-----, "What is FANS," 30 August 1996.

Nader, Ralph and Wesley J. Smith. *Collision Course: The Truth About Airline Safety*. Blue Ridge Summit: TAB Books, 1994.

Nordwall, Bruce D. "Free Flight: ATC Model for the Next 50 Years," *Aviation Week & Space Technology*. 38-39 (31 July 1995a).

-----, "FANS-1 Benefits Near on Pacific Routes," *Aviation Week & Space Technology*. 28-29 (4 September 1995b).

-----, "Free Flight Could Stall Without Key Data Link," *Aviation Week & Space Technology*. 28-29 (3 June 1996).

Phillips, Edward H. "Free Flight Poses Multiple Challenges," *Aviation Week & Space Technology*. 27 (25 March 1996a).

-----, "Wilcox Draws FAA's Ire Over WAAS," *Aviation Week & Space Technology*. 28 (25 March 1996b).

-----, "ATC Upgrades Focus of FAA Budget Request," *Aviation Week & Space Technology*. 28 (25 March 1996c).

Rutherford, Robert L. "Working Together for Defense Transportation System 2010," *Defense Issues, Volume 10*, Number 30: 1-13 (23 February 1995).

World Almanac and Book of Facts 1996. New Jersey: Funk & Wagnalls, 1995.

Vita

Major Joe Craig Herron was born on 19 May 1961 in Oklahoma City, Oklahoma. He graduated from Norman High School in 1980 and entered undergraduate studies at the United States Air Force Academy in Colorado Springs, Colorado. He graduated with a Bachelor of Science degree in May 1984.

His first assignment after undergraduate pilot training was at Williams AFB as a T-37 instructor pilot. His next assignment was at Travis AFB as C-5 Chief Aircrew Standardization and Evaluation Pilot for the 75 MAS. He continued his flying career as a Flight Commander and Examiner Pilot in the KC-10 at March AFB. While at March AFB, he earned a Master of Arts degree in Humanities from California State University. In September 1995, he entered the Advanced Studies of Air Mobility Program, Air Force Institute of Technology.

Permanent Address: 226 Westside Drive
Norman, OK 73069

REPORT DOCUMENTATION PAGEForm Approved
OMB No. 074-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE November 1996	3. REPORT TYPE AND DATES COVERED Graduate Research Paper	
4. TITLE AND SUBTITLE LOOKING TOWARDS THE FUTURE AIR NAVIGATION SYSTEM:WILL FREE FLIGHT HAMPER GLOBAL REACH?			5. FUNDING NUMBERS	
6. AUTHOR(S) Joe C. Herron, Major, USAF				
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology 2750 P Street WPAFB OH 45433-7765			8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GMO/LAL/96N-2	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) HQ AMWC/WCOA Ft Dix NJ 08640			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 Words) Budget constraints are forcing prioritization on future spending for Air Mobility Command's weapon systems. As the airplanes age, some of the parts that are worn out become too expensive to replace. Modernization of avionics and communication packages are becoming a necessity based on the rapid implementation of the Future Air Navigation System (FANS) and Free Flight. The purpose of this study is to understand how the implementation of FANS will affect the Air Mobility Command's Global Reach Mission in the 21 st Century. A background and literature review will show what elements comprise FANS and Free Flight. The strategic planning of the Air Mobility Master Plan (AMMP) and a new directive closes the review. The main issues of technology, concepts, and costs will be discussed along with the two alternatives available to AMC for future emphasis. The study concludes with the emphasis that a new planning method has to be implemented. The priority for avionics and communications upgrades is now. The operations tempo will not slow down in the near future. The policy of Global Reach will continue to be called upon. We must see that unrestricted operations in the FANS and Free Flight environment continues.				
14. SUBJECT TERMS Future Air Navigation System, FANS, Free Flight,			15. NUMBER OF PAGES 44	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT research. **Please return completed questionnaire** to: AFIT/LAC BLDG 641, 2950 P STREET, WRIGHT-PATTERSON AFB OH 45433-7765 or e-mail to dvaughan@afit.af.mil or nwiviott@afit.af.mil. Your response is **important**. Thank you.

1. Did this research contribute to a current research project? a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?
a. Yes b. No

3. **Please estimate** what this research would have cost in terms of manpower and dollars if it had been accomplished under contract or if it had been done in-house.

Man Years _____ \$ _____

4. Whether or not you were able to establish an equivalent value for this research (in Question 3), what is your estimate of its significance?

a. Highly b. Significant c. Slightly d. Of No
Significant Significant Significance

5. Comments (Please feel free to use a separate sheet for more detailed answers and include it with this form):

Name and Grade

Organization

Position or Title

Address